

Spectrum developments in Europe

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Outline

UHF

700 MHz

Longer term
opportunities

<6 GHz

L-Band

Licensed Shared Access

2.3 and 3.5 GHz

LTE-U

5G

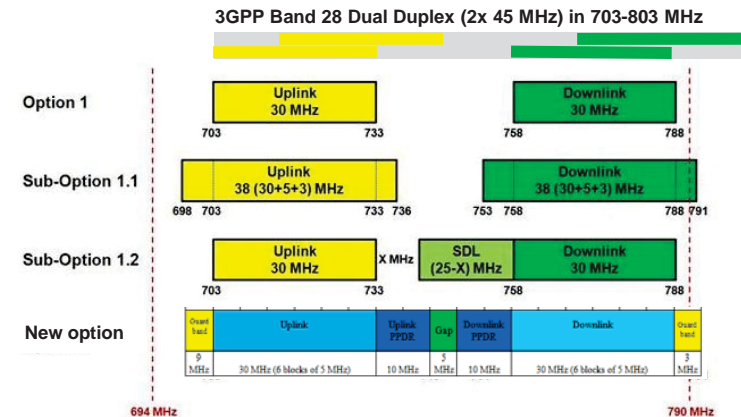
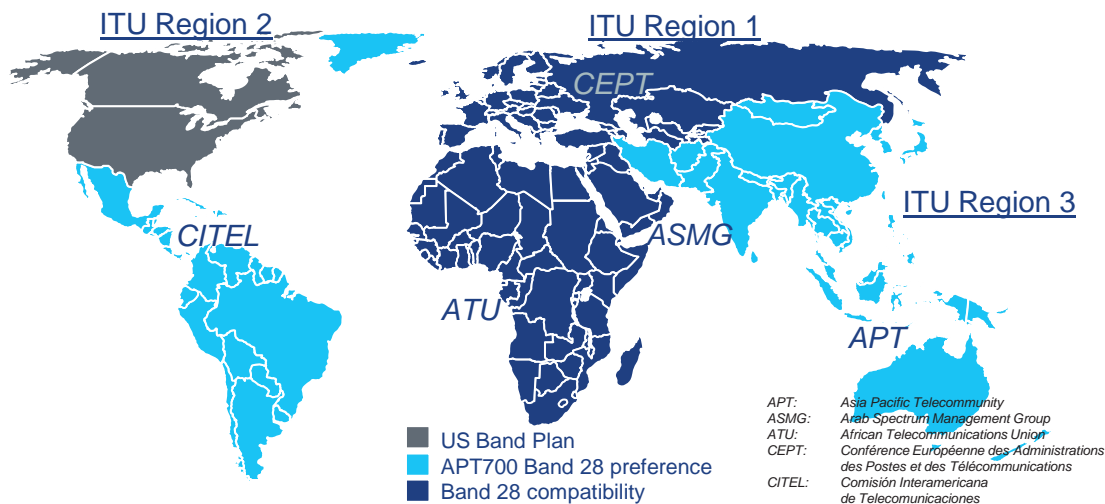
Vision

Technologies

Timelines

Spectrum

Close-to-global harmonization in 700 MHz based on APT-700 band plan / 3GPP Band 28



CEPT band plan options

- non compatible option 2 with 2x 40 MHz dismissed
- option 1 selected with freedom to implement in compatible sub-options 1.1, 1.2 or new option

Now including CEPT with options to use duplex gap and guard

- ECC decision drafted for 2x 30 MHz lower duplexer of Band 28 with -48 dBm/8 MHz out of band emission requirement
- The duplex gap may be used for Supplemental Downlink, PMSE or PPDR

700 MHz Band 28 availability globally

In operation in AUS and NZ, supported by upper end of recent device range

700 MHz band awards Brazil in Aug 2018 and Honduras in Sep 2018

Finland and Sweden (“the usual suspects”) announced availability in 2017

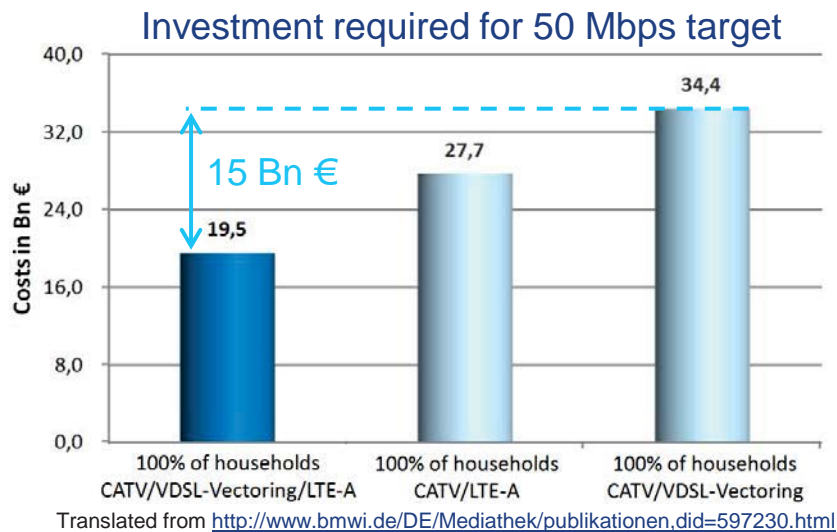
France considering an auction 2015, band availability in uncertain

Germany plans auction 1H15 with nationwide availability 2H19 (only after completion of DVB-T2 migration) targeting regional availability before E2018 to prove progress on national 50 Mbps broadband target 2018

For UK, OFCOM stated “not before 2018” initially, 2022 or earlier in current OFCOM strategy

EU High Level Group report of Pascal Lamy to the European Commission on UHF proposes 2020 +/-2 years for EU, echoed recently in RSPG opinion draft under consultation

15 Bn € cost saving opportunity on the investment required for the German broadband targets by including LTE-A Carrier Aggregation and 700 MHz



Threats:

Late clearing from DTT delays broadband target achievement

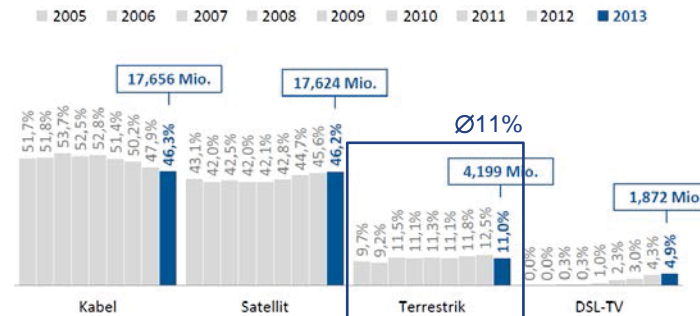
☹ German DVB-T2 migration until 1H19

Exclusive spectrum demand of PPDR in 700 MHz would block large parts of the band

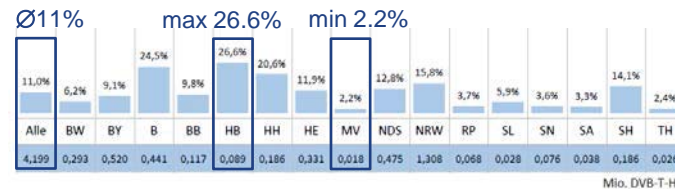
☺ all 2x 30 MHz in German auction

- TÜV Study: a mix of all technologies is required to cost-efficiently achieve 100% target of 50 Mbps by 2018
- To transport 50 Mbps over several km, sufficient bandwidth below 1 GHz is required
This can be provided in combined 800 MHz and 700 MHz frequency resources technically addressed with LTE Carrier Aggregation

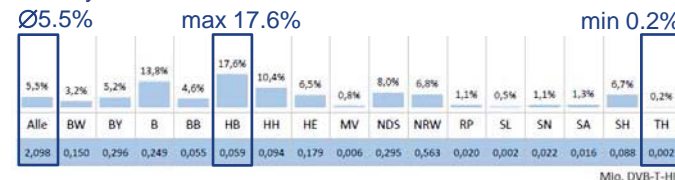
In the state of Thüringen, 2000 households prevent 320 MHz of prime UHF spectrum from possible use for Mobile Broadband



Total use



Primary use



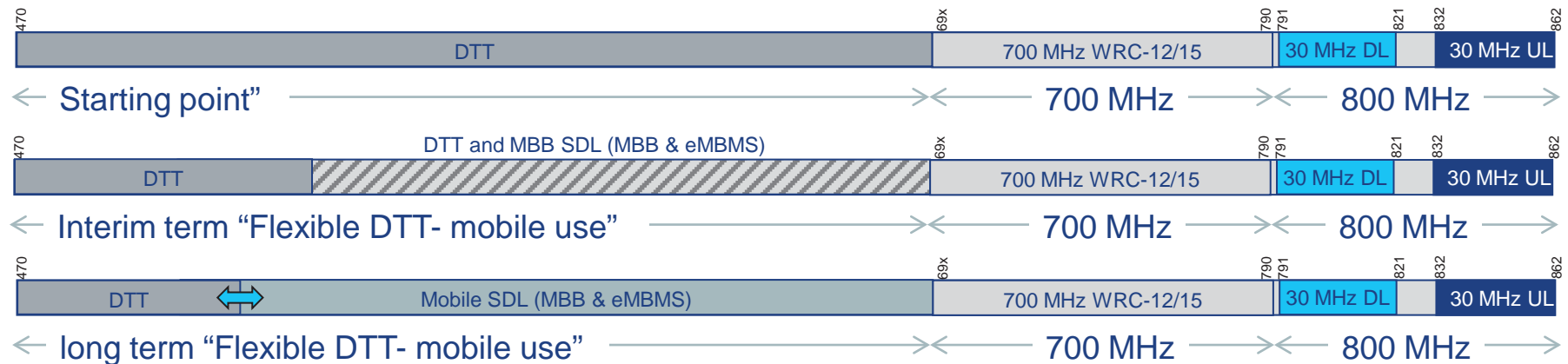
In Germany, an average of 11% households uses DVB-T as a source for TV, 5.5% depend on DVB-T

DVB-T use ranges between 2.2% and 26% subject to private TV offer

Between 0.2% and 17.6% of the households rely on DVB-T exclusively

Source: http://www.die-medienanstalten.de/fileadmin/Download/Publikationen/Digitalisierungsbericht/2013/Bericht_Digitalisierungsbericht_2013.pdf

Supplemental Downlink (SDL) - A flexible way to introduce Mobile Broadband in the UHF band where no additional bands can be cleared for FDD any time soon



SDL is downlink only and thus well compatible with DTT, even within Geneva-06 agreements

SDL allows for harmonised wide band RX devices to address scattered spectrum in 470-694 MHz

SDL adds DL capacity to Mobile Broadband networks via LTE-A carrier aggregation

Within SDL, eMBMS can be used to efficiently carry linear traffic, based on market demand

Vision 2020+: mobile allocation in 470-698 MHz and Supplemental Downlink for ubiquitous video and TV across the full device range



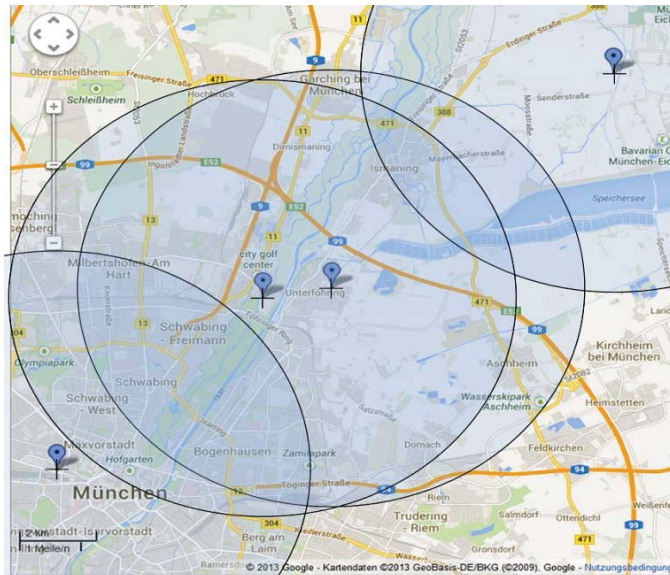
Wide choice of linear live TV programs and individual non-linear offering consistently across multiple device types

Full Mobility: at home not only in the living room, at the station, on the train, even underground, in the car ...

Fully interactive capabilities
e.g. active participation in shows

First successful field trial in Germany

Implemented with commercially available Flexi eNodeB hardware



Q2/14: Field trial
Prototype with SFN*
available

Q4/14: Demo center
Available for customer
visits

Configuration

- > eMBMS and SFN* on Nokia Flexi Multiradio 10 BTS
- > Core network emulation
- > 4 cells in SFN* operation, 4 locations, QC terminals
- > UHF spectrum, band 28, to analyze coverage conditions
- > 10 MHz (several SD channels, some HD channels)

*) SFN: Single Frequency Network

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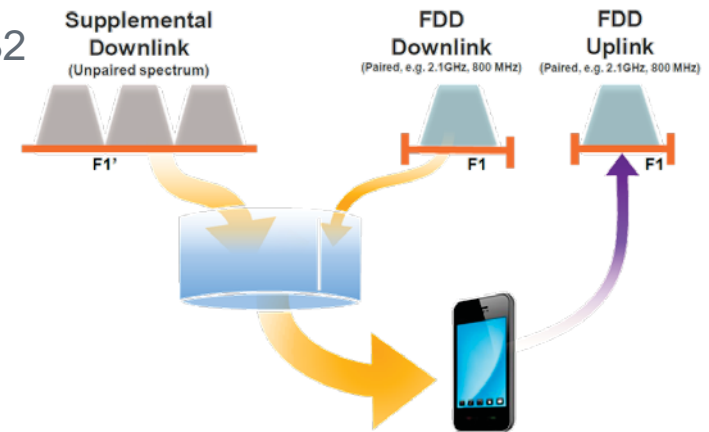
“L-Band” 1452-1492 MHz for Supplemental Downlink (SDL)

Technically

- CEPT report 188
- 3GPP Band 32, CA band combination 20 (EU800)+32
- Qualcomm 9x30 chipset support since Oct 2014

Spectrum availability

- UK in L-Band owned by Qualcomm
- Italy planning auction in 2015
- France rumoured to plan auction in 2015
- Germany part of proposed auction 1H15



Opportunity: substantial DL capacity upgrade at moderate (?) spectrum cost

Challenge: site upgrade cost (antennas, feeding systems, mast loads, ...)

Harmonization and global standards drive economies of scale

Spectrum usage models



Mainstream Approach Auctions of Cleared Spectrum

Exclusive Use
Ensures
Quality of Service



Complementary License Model Licensed Shared Access

Exclusive Shared Use
*Exclusive use on a shared and binary
basis in Time, Location, and/or Frequency
with Incumbent (government, defense etc.)*
Predictable Quality of Service



Shared Approach Unlicensed (Wi-Fi, LTE-U, ...)

Shared Use
Unpredictable
Quality of Service

Wi-Fi has simple in-built autonomous rules w/o central control

Heavy traffic requires management of the scarce resource

Wi-Fi uses carrier sense multiple access with collision avoidance (CSMA/CA), c.f. “roundabout rules”

- works fine for limited #users, moderate load
 - prone to blocking at high number #users, high loads
unpredictable impact of other Wi-Fi and other services in unlicensed band
- good performance at low load, zero throughput at extreme load



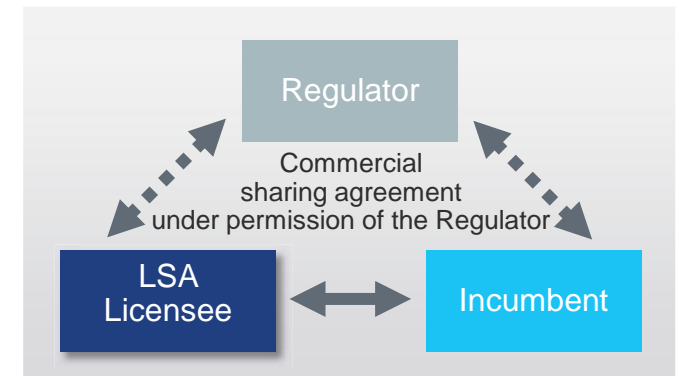
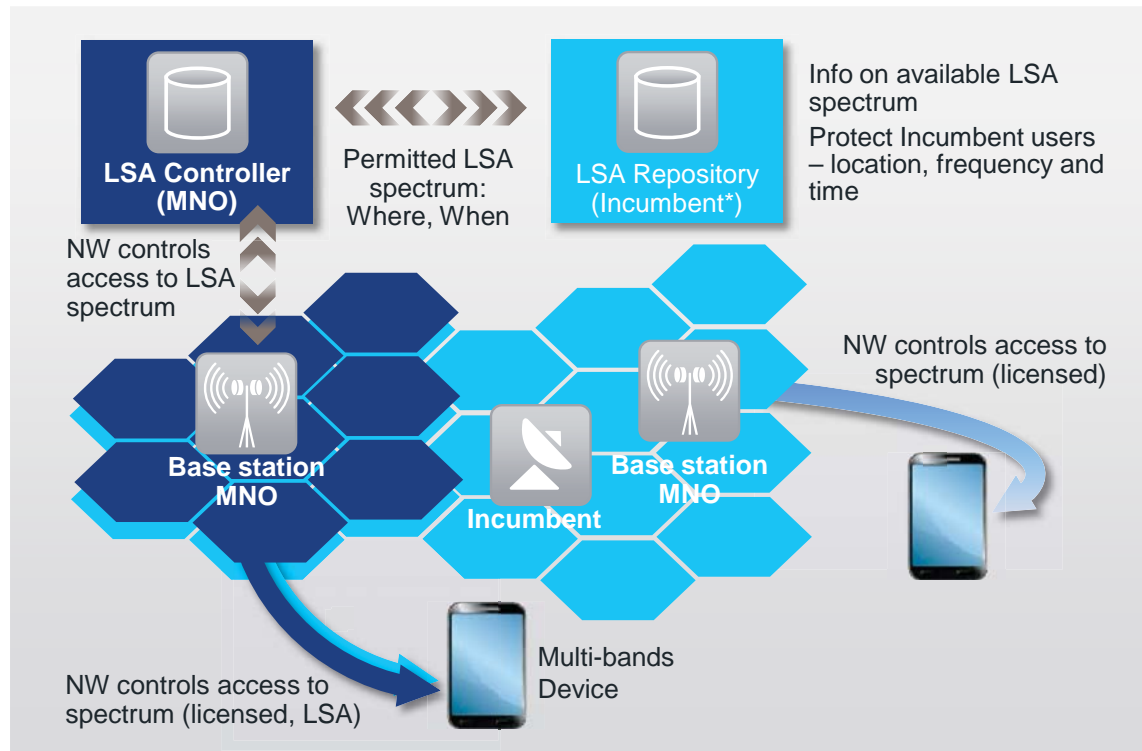
Cellular uses network controlled scheduling to assign resources to users according to their demand, c.f. “intelligent traffic lights”

- works fine for any #users at any load even if data rate needs to be shared among users
- good performance at low load, predictable and best possible performance at high load



A new way of licensing mobile broadband spectrum - Licensed Shared Access (LSA)

LSA is a simple concept which can be implemented today using available terminals and network



Regulatory framework

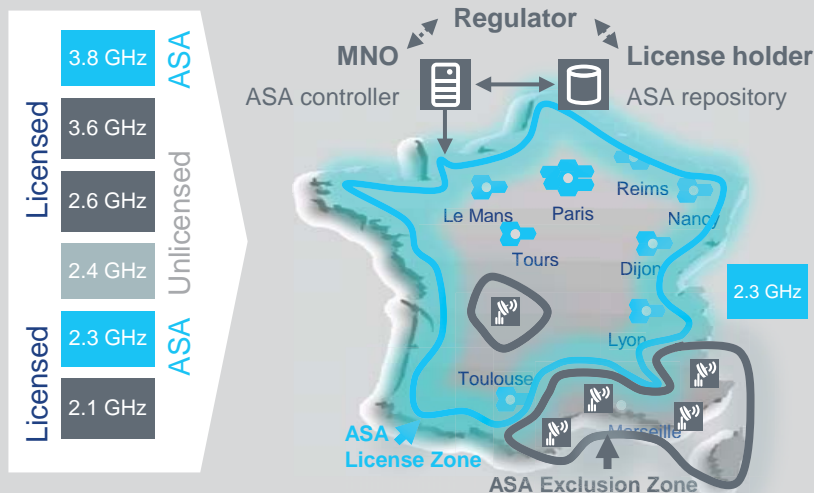
- LSA spectrum to be licensed is identified by the government
- Subject to a private commercial agreement between incumbent and LSA licensee

Licensed Shared Access, or Authorized Shared Access (ASA)

Unlock more spectrum e.g. in 2.3 GHz with predictable QoS

Our approach

- Enables timely availability and licensed use of harmonized spectrum with predictable QoS



Operator benefits

- Accelerates spectrum harmonization
- Leverages available LTE technologies to ensure early use and Economy of Scale
- Opportunity for lower cost and high quality licensed spectrum

Innovation examples



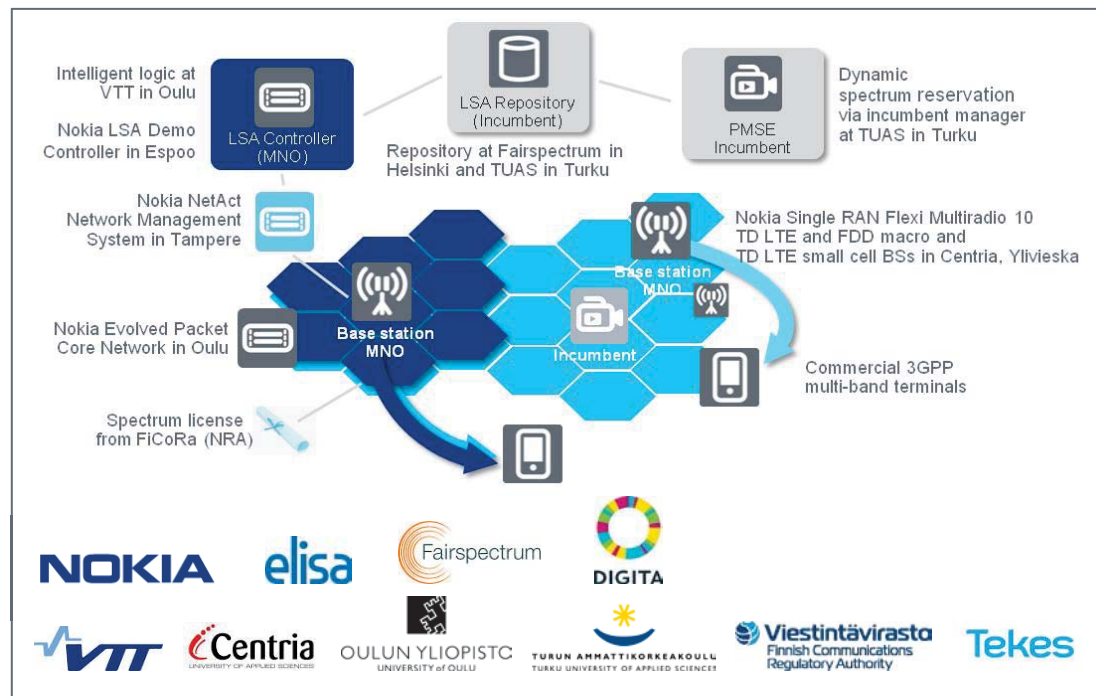
World's first ASA trial 06/2013



ASA demo

World 1st LSA over the air field trials proved the concept

LSA TD LTE 2300 with PMSE over the air field trial with e2e Finnish ecosystem



Trial included full e2e LSA ecosystem in Finland: regulator, incumbents, MNO and supplying industry in CORE+ project

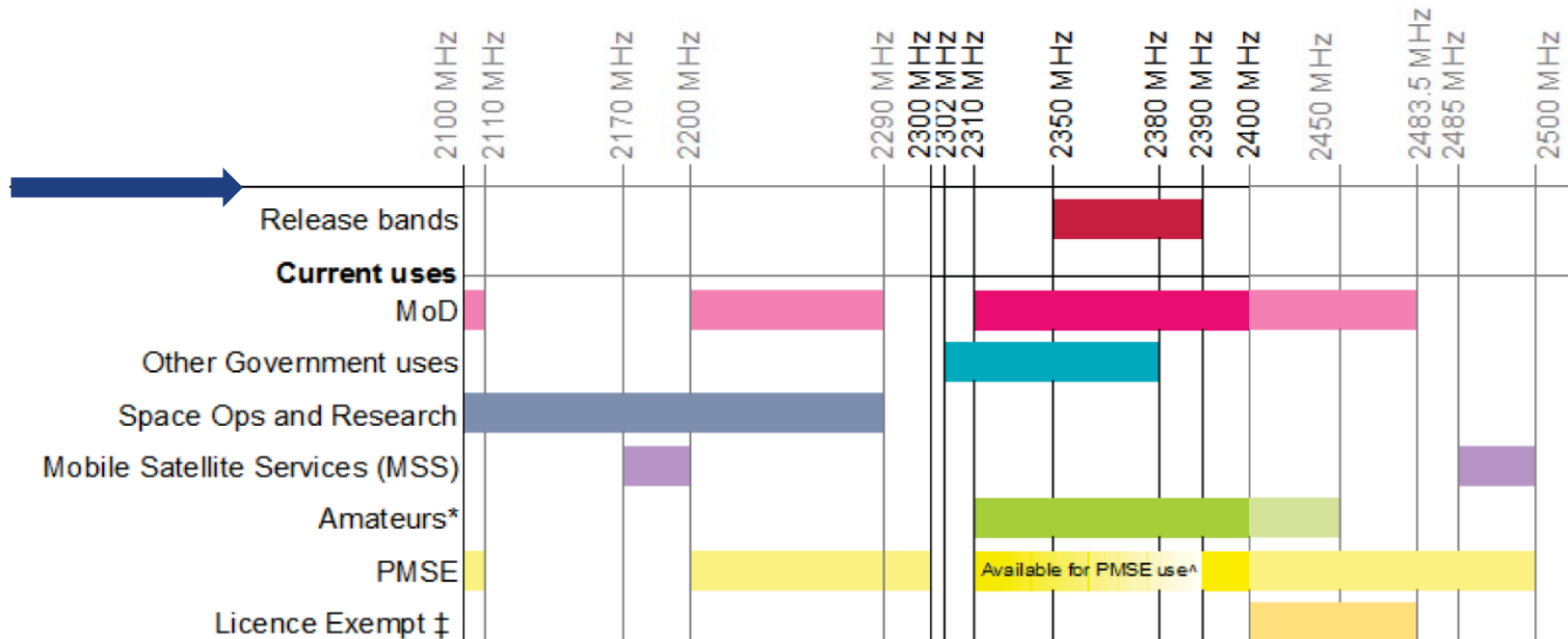
LSA Ecosystem

Nokia in Research – Standardization – Regulatory Bodies and Administration



UK first in EU to release 2.3 GHz increasing momentum in the region

UK 2.3 GHz band use - 40 MHz (2350-2390 MHz) to be auctioned exclusively, Band 40



* 2400 to 2450 MHz may also be used by the amateur satellite service

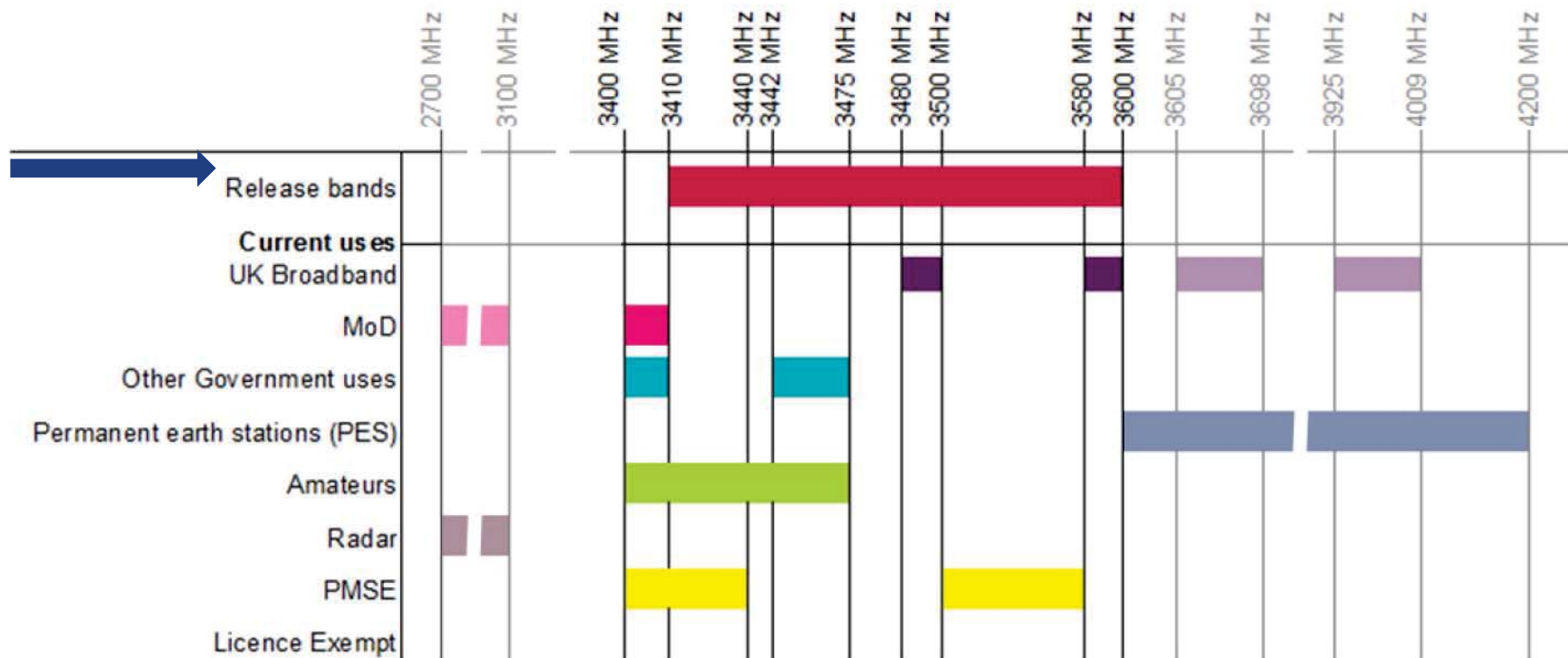
‡ 2400 to 2500 MHz is designated for Industrial, Scientific and Medical (ISM) applications

^ The band 2300 to 2390 MHz is used by PMSE on a loan basis agreed with MoD and other government departments

Source: <http://stakeholders.ofcom.org.uk/consultations/pssr-2014/>

UK to release additional spectrum in 3.5 GHz

UK 3.4 GHz band use - up to 150 MHz in 3410-3600 MHz, Band 42 TDD preferred



Source: <http://stakeholders.ofcom.org.uk/consultations/pssr-2014/>

Use of unpaired bands for downlink, e.g. in 2.6 GHz

Supplemental Downlink vs. up to 100% downlink via LTE-A Carrier Aggregation

Supplemental Downlink (SDL)

- Requested by some global operators to optimally use unpaired bands like the 2.6 GHz in DL direction only
- Inline with earlier ideas of using e.g. 2.6 GHz unpaired band as external DL band
- Could split the device ecosystem into devices supporting TDD in the band, others supporting SDL and a third fraction supporting both
- Typically considered as FDD and consequently objected by major TDD players

Flexibility in TDD up to 100% DL

- Like SDL, requires another (FDD or TDD) band as primary component carrier for LTE-A Carrier Aggregation
- Technically (from a spectrum analyser's perspective) similar result like SDL
- “wastes” UE TX capability in 100% DL use case (marginal cost drawback)
- Maintains a common ecosystem
- Even pushes TDD support as default into devices, as iPhone 6 could have 2 variants (FDD+TDD, FDD+TDD+CDMA) in stead of 3 variants (FDD, FDD+CDMA, FDD+CDMA+TDD) with TDD only supported in the highest tier

20 bands supported in Apple iPhone 6 & 6 Plus at European operators

iPhone 6

Model A1586 (GSM)

Model A1586 (CDMA)

iPhone 6 Plus

Model A1524 (GSM)

Model A1524 (CDMA)

1 (2100 MHz)

2 (1900 MHz)

3 (1800 MHz)

4 (AWS)

5 (850 MHz)

7 (2600 MHz)

8 (900 MHz)

13 (700c MHz)

17 (700b MHz)

18 (800 MHz)

19 (800 MHz)

20 (800 DD)

25 (1900 MHz)

26 (800 MHz)

28 (700 APT MHz)

29 (700 de MHz)

38 (TD 2600)

39 (TD 1900)

40 (TD 2300)

41 (TD 2500)



United States

Appalachian Wireless

Bluegrass Cellular

Boost

C Spire

Cellcom

Chariton Valley

Chat Mobility

Defense Mobile

MobileNation

Nex-Tech

NorthwestCell

nTelos

Pioneer Cellular

Sprint

STRATA Networks

Syringa

Thumb Cellular

United Wireless

US Cellular



Australia

Optus (including Virgin)

Telstra

Vodafone



Germany

Deutsche Telekom

O2

Vodafone

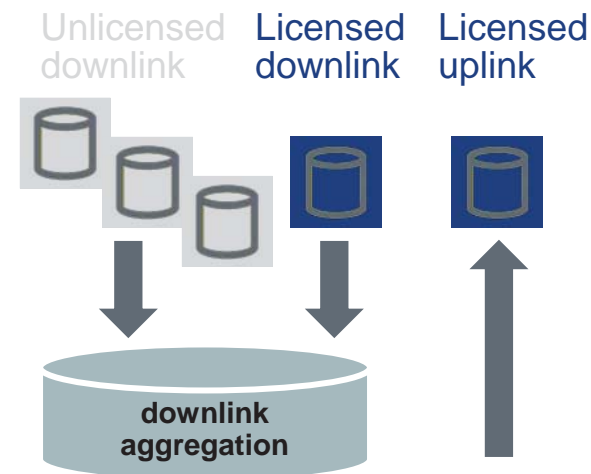


www.apple.com/iphone/LTE/

NOKIA

LTE for Unlicensed Bands (aka LTE-U) - Licensed-Assisted Access using LTE

Standalone use or - as an early implementation - with downlink carrier aggregation



- Unique combination of **licensed** + **unlicensed** bands
- Licensed band provides reliable connection and quality of service for mobility, signaling, voice and data
- Unlicensed band boosts data rates – "Opportunistic use"
- LTE-U to be integrated into small cells beside Wi-Fi
- Downlink:uplink asymmetry up to 10:1 in LTE networks
- Targets public hotspots managed by operators



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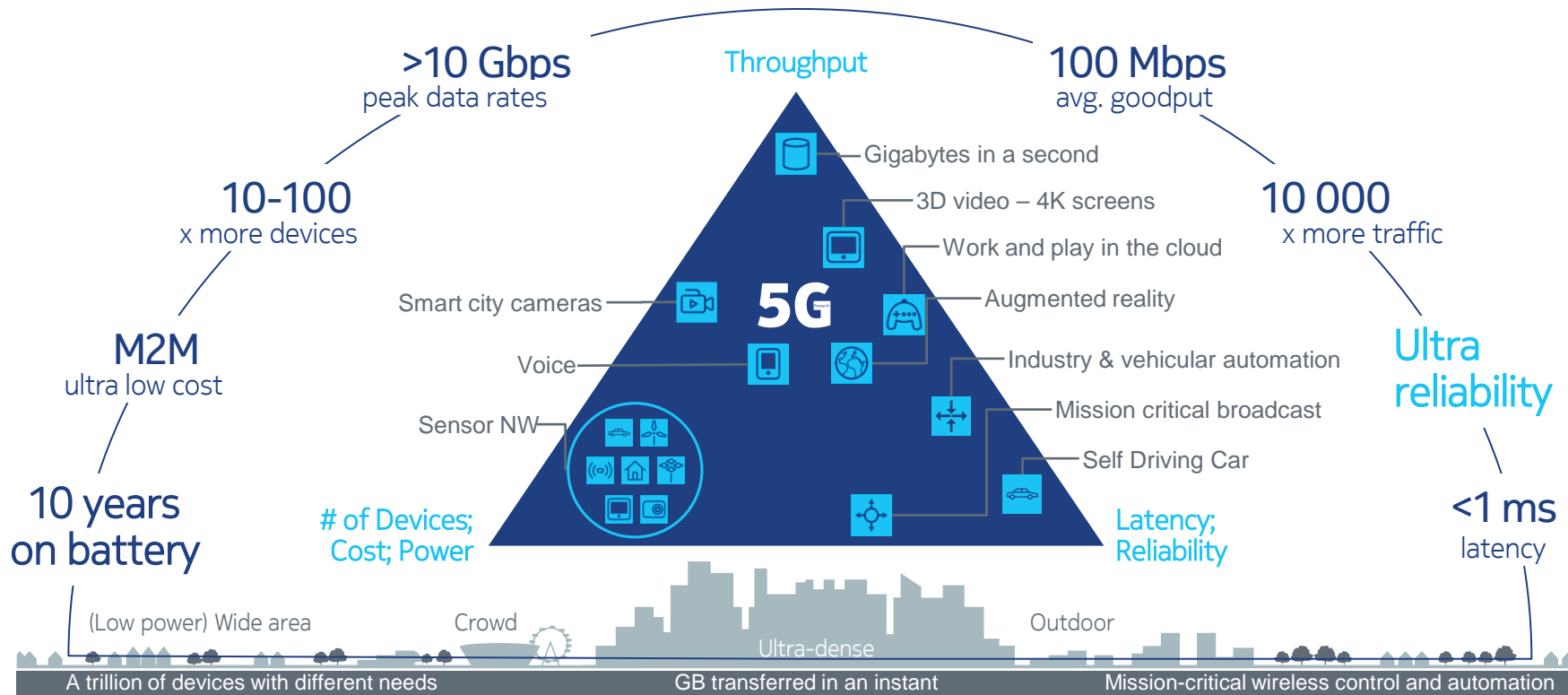
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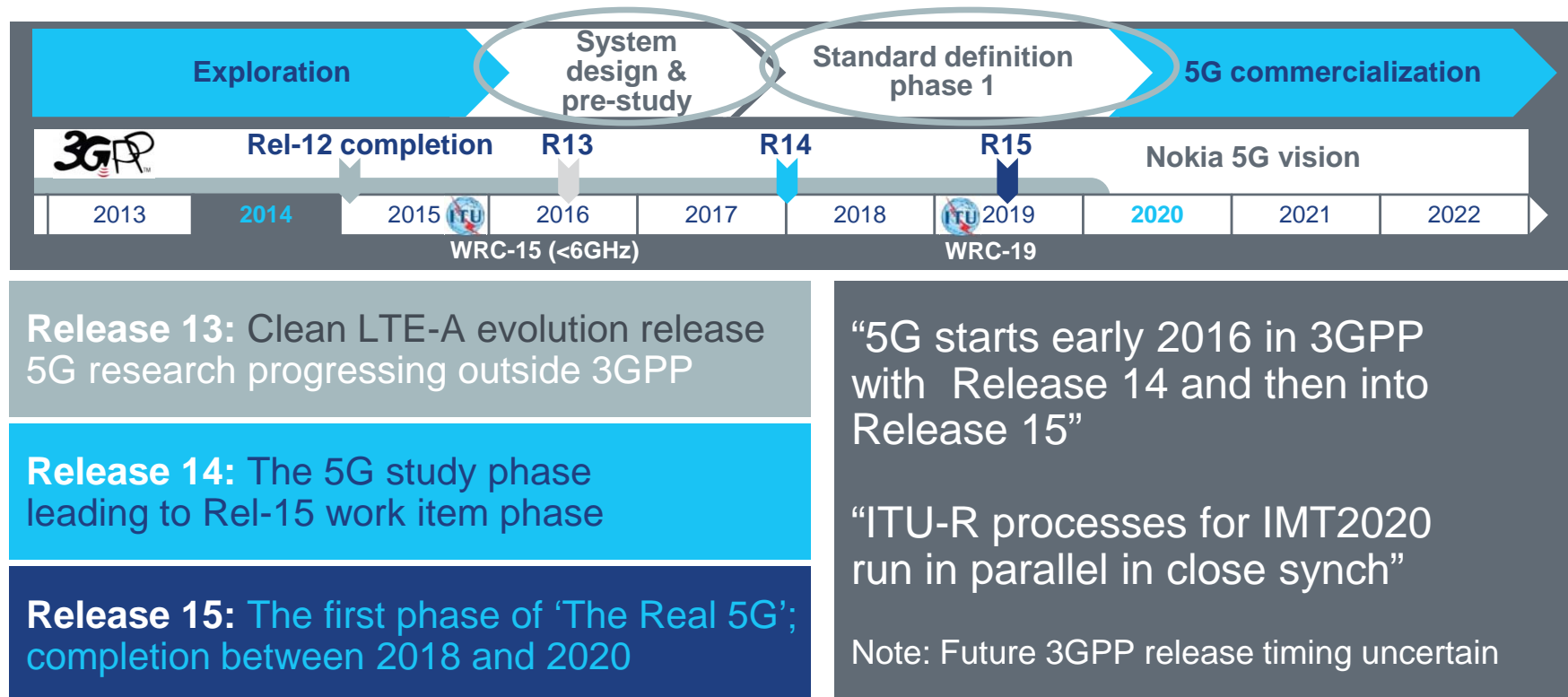
5G will expand the human possibilities of the connect world



5G technologies under study

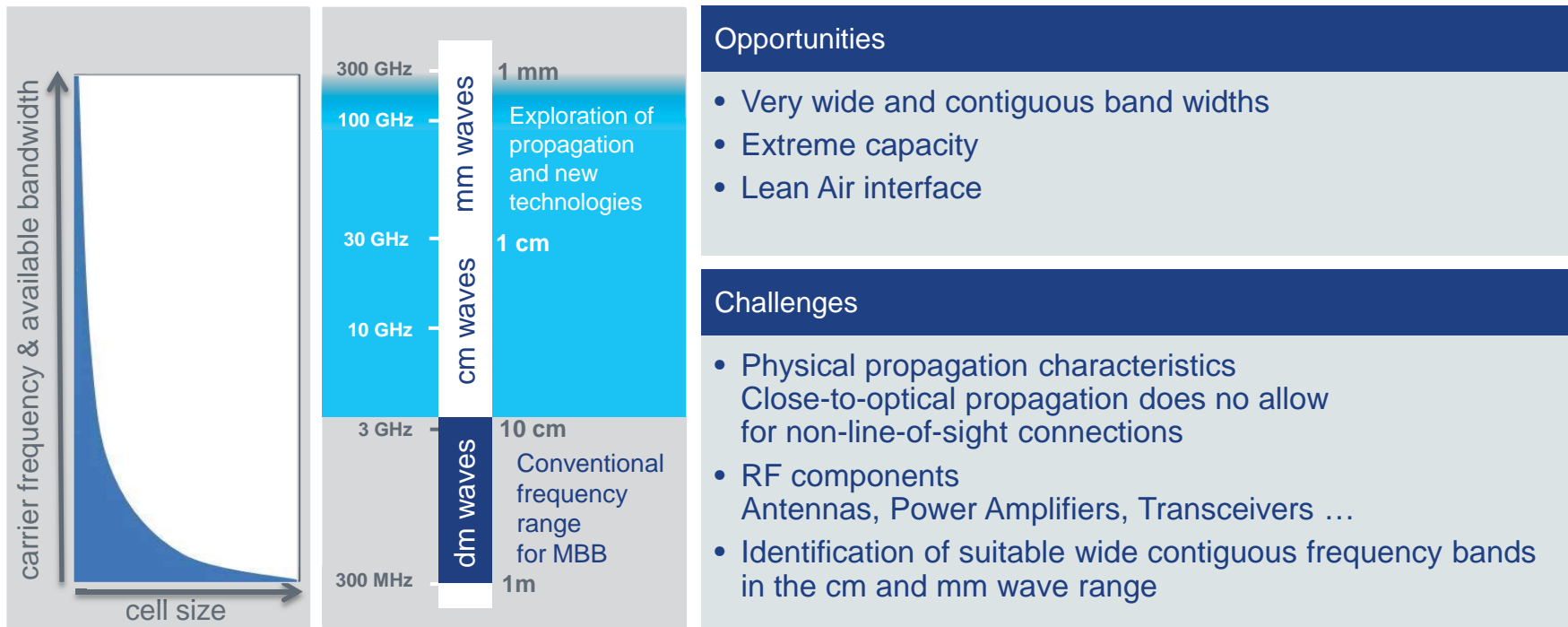
Spectrum access and efficiency	<p>Massive MIMO and massive beam forming</p> <p>3...6 GHz: Spectral efficiency (MIMO), >> 6 GHz more about path gain (BF)</p>	<p>Centimeter-Wave and Millimeter-Wave</p> <p>Spectrum access, for dense deployments</p> 	<p>New waveforms and modulations</p> <p>Must be justified by gains, compatibility with MIMO essential</p>	Reliability – Flexibility – Scalability	
	<p>Multi-RAT integration</p> <p>5G is integrating novel and existing radio access technologies</p>	<p>Radio virtualization</p> <p>Parts of radio will be virtualized, need for specialized L1 HW may still persist</p>	<p>Flexible networking</p> <p>Local gateway/services Per-service tailored feature set (mobility, QoS, latency etc.)</p>		

5G from research to standards



Bridging the spectrum gap to deliver extreme capacity in 5G

High hope, high risk: additionally exploring frequencies above 6 GHz



Some 5G Spectrum & Regulatory Updates

Initiate a new round of Detailed Spectrum Investigation (DSI) for above 6GHz in CEPT

- Industry would like to get IMT spectrum for 5G in WRC2019.
- Need information about current usage and incumbents' future plans, not just allocation.

CEPT activities towards WRC2015 AI10 ECC (PT1 & CPG PTA)

- In ECC PT1 a working document exists to collect response to PTA liaison to PT1 on >6GHz spectrum
- 1st draft by January 2015 and final draft by April 2015

Assessment of frequency ranges / bands 6 – 100 GHz

Bands having a **worldwide (co)primary allocation to Mobile Service** have most potential for spectrum designation

Not all bands with (co)primary allocation to Mobile Service may be suitable for IMT designation
Therefore, detailed studies are needed to assess the suitability

Current use

Actual usage (not just allocation) of the frequency ranges should be further investigated

Footnotes

ITU RR and ECA Table footnotes should be examined to find out restrictions and prohibitions

Interference

Situation and/or probability of interference should be considered

Channel bandwidth

Regulator-assigned channel bandwidths need to be assessed

Contiguous spectrum

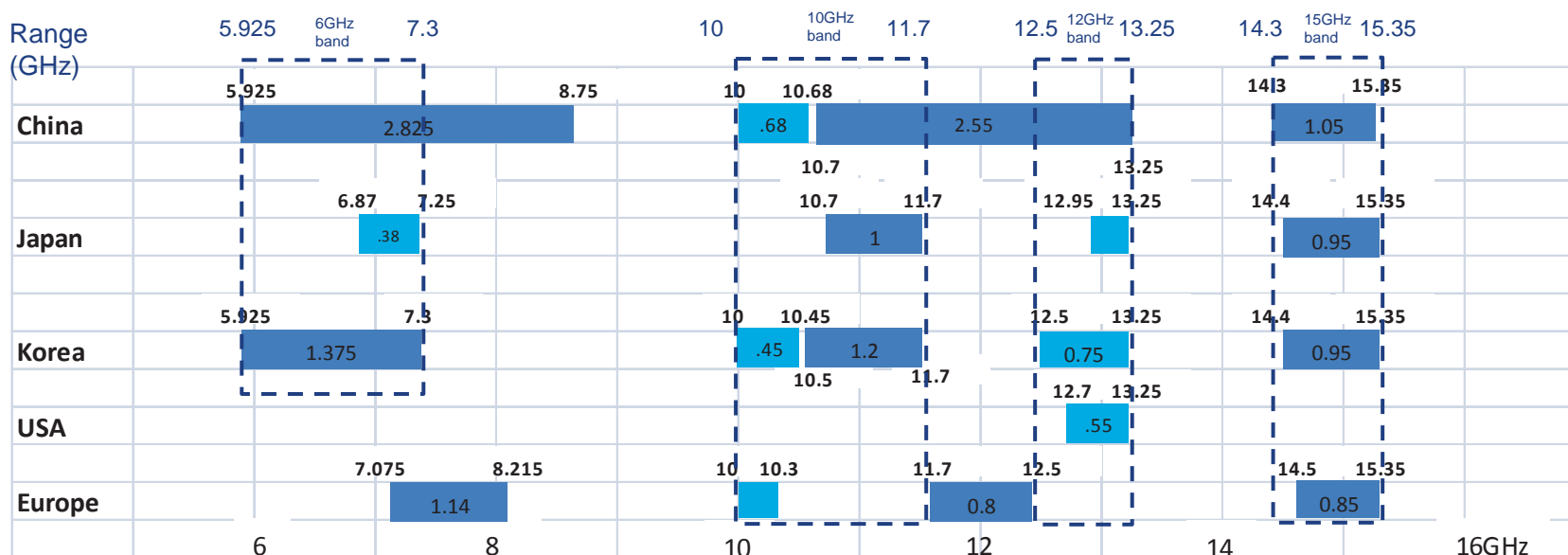
E.g. minimum 300 MHz of contiguous spectrum needed for a band to be suitable

Channel characteristics

Channel/path loss model needs to be studied.

Mapping Bands to 5G Requirements

6-16GHz, Co-Primary Mobile Allocation, min. 300MHz Contiguous Spectrum

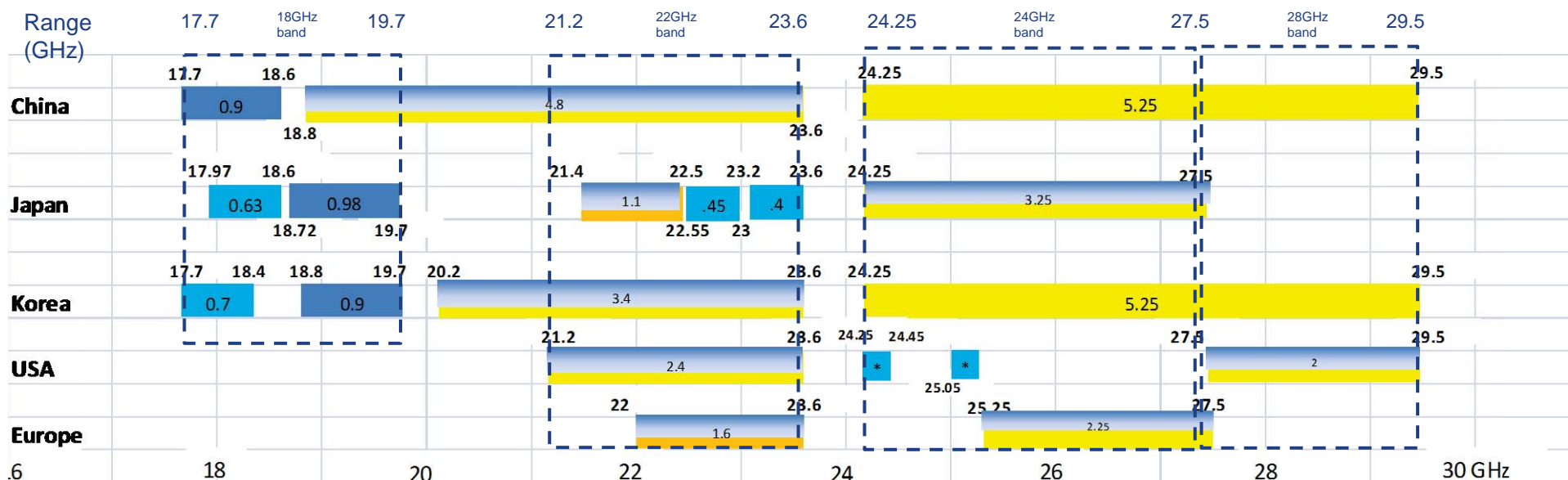


High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz.

High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz & Spectrum Sharing among operators

Mapping Bands to 5G Requirements

16-30GHz, Co-Primary Mobile Allocation, min. 300MHz Contiguous Spectrum



High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz.

High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz & Spectrum Sharing among operators

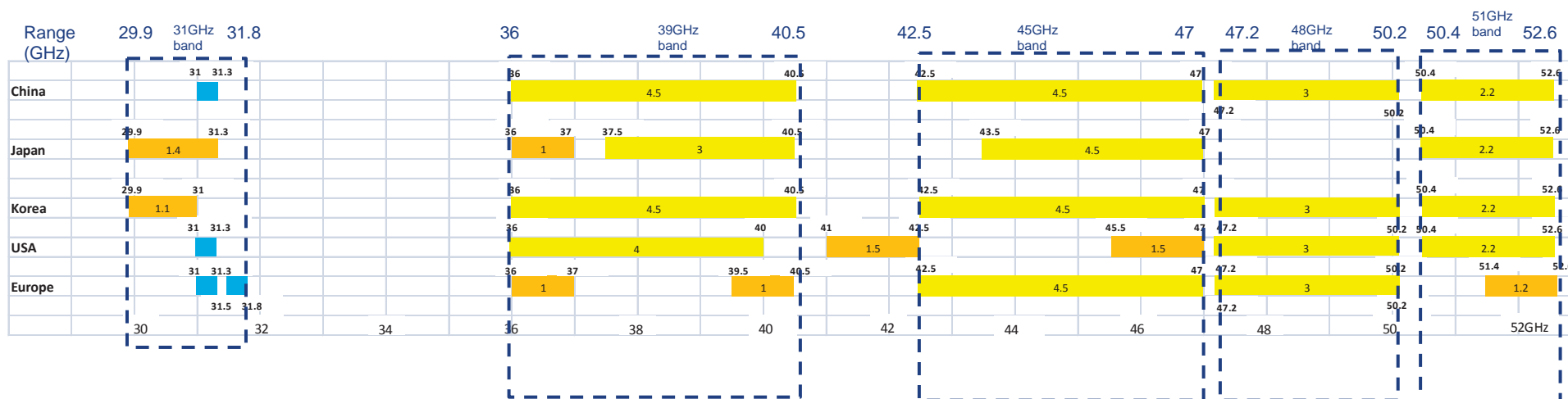
Low rank MIMO for system BW in excess of 1 GHz with no interference management schemes

Low rank MIMO for system BW in excess of 1 GHz with no interference management schemes & Spectrum Sharing among operators

* 24GHz Band with No Mobile Allocation being considered by FCC

Mapping Bands to 5G Requirements

30-54GHz, Co-Primary Mobile Allocation, min. 300MHz Contiguous Spectrum



High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz.

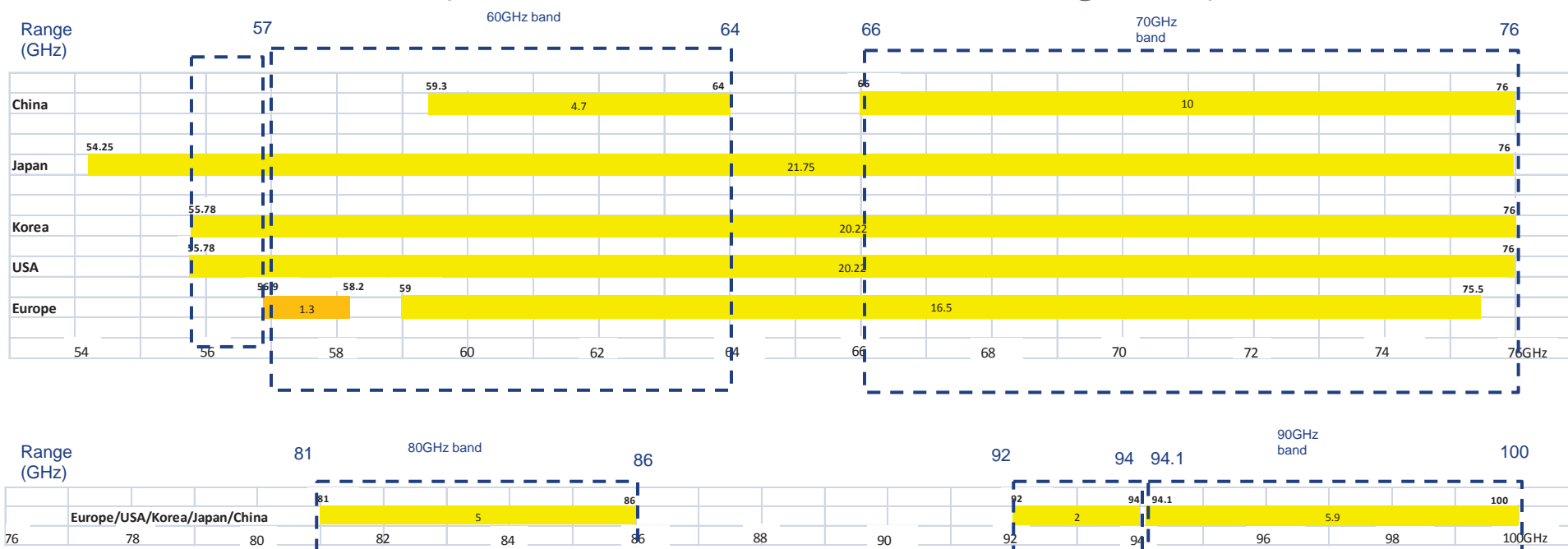
High rank MIMO (SU/MIMO) and CA, Interference Management schemes for system BW < 400 MHz & Spectrum Sharing among operators

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Mapping Bands to 5G Requirements

54-100GHz, Co-Primary Mobile Allocation, min. 300MHz Contiguous Spectrum



Low rank MIMO for system BW in excess of 1 GHz with no interference management schemes

Low rank MIMO for system BW in excess of 1 GHz with no interference management schemes & Spectrum Sharing among operators

We invite you to see our 5G demos @ MWC 2015

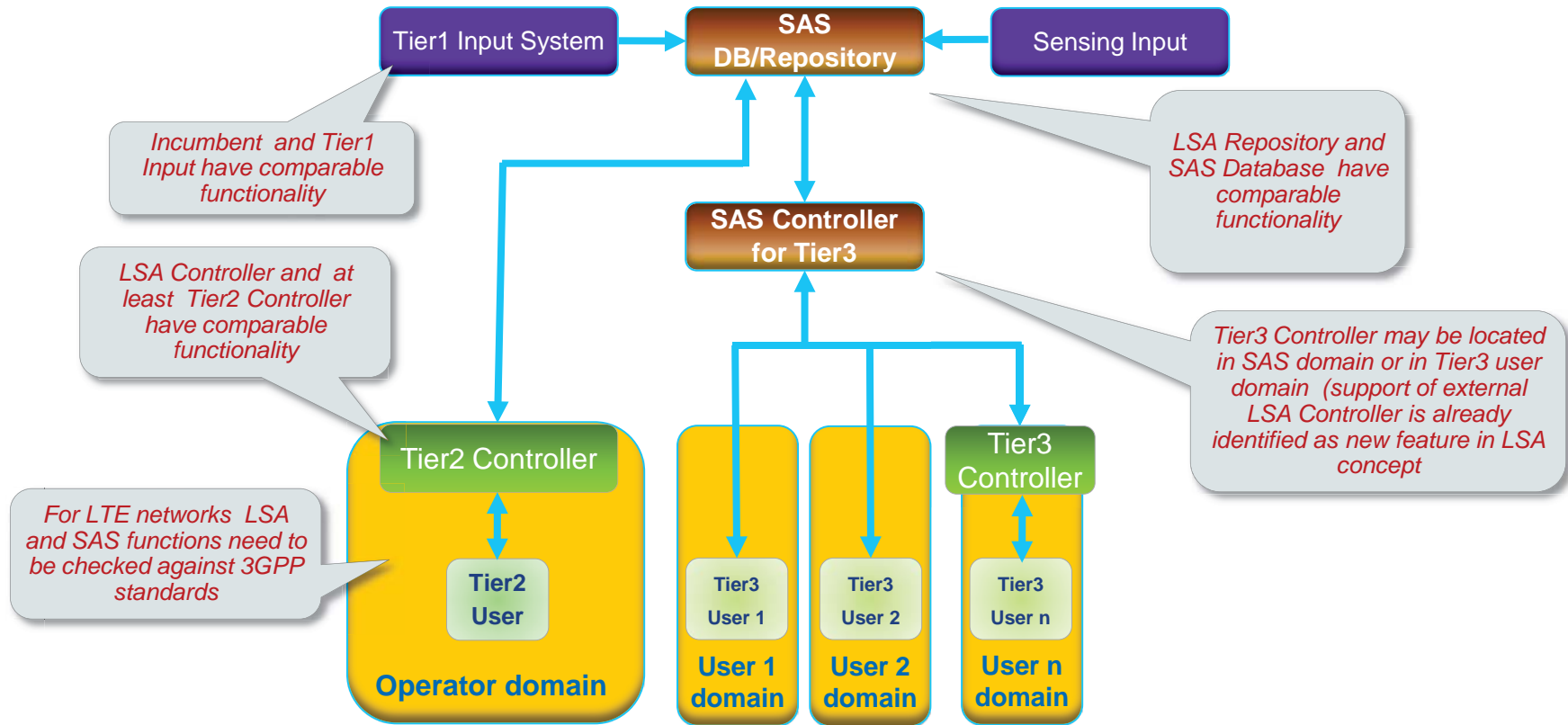
www.brooklyn5Gsummit.com

<http://networks.nokia.com/innovation/5g>

Thanks for your time!

SAS – Architecture

Comparing of LSA and SAS functions



SAS - Architecture

Options for SAS 3-tier architecture with LSA support

NRA Access

- Supervision of Spectrum usage via 8

Tier2 Spectrum Usage control (LSA)

- Spectrum availability information via 1 (LSA1 interface)
- Spectrum availability mapping via A (3GPP Itf-N) + self detection option via C

Tier3 Spectrum Usage control

- Spectrum availability information via 3 2 using GA User owned Tier3 Controller and spectrum availability mapping via B A
- Spectrum availability information via 4 using SAS Controller directly

SAS internal Interfaces

- Communication between SAS Database and SAS Controller via 7

